

EVALUATING DISPROPORTIONATE EXPOSURE: Southern California Regional Patterns and Environmental Justice

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Arc of Our Research - Environmental Justice & Community Health



- Demonstrating Disparities in Exposure
- Analyzing Determinants of these Disparities in a Multivariate Model
- Understanding Evolution of the Contemporary Pattern
- Documenting Associated Potential Health Risks from Cumulative Exposure
- Other Consequences - Children's Health and Learning



Environmental (In)Justice in Southern California: Research Results

Persistent racial/ethnic disparities:

- In location of industrial facilities and hazardous waste TSDs
- Originally disproportionate siting explains current pattern of disparate impact, not market forces (“minority move-in”)
- Exposure to TRI air releases, cumulative ambient air pollutants and associated health risks
- Environmental hazard exposures among public school children correlates with adverse impacts on academic performance
- Burdens fall most heavily on Latinos and African Americans (income independent)
- Similar results using 1990 and 2000 Census



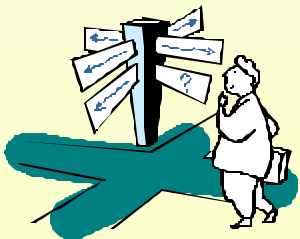
Analytical Strategy – Compare demographics of areas with relatively high exposure, to those with lower exposure to hazards, hazardous releases, measurable impacts.

- Determine regional pattern of exposure (residential, schools)
- Spatial analysis using GIS
- Univariate analysis of spatial results
 - “ t test”; Wilcoxon signed ranked test
 - Identify determinants for multivariate
- Multivariate analysis
 - Binomial and ordered logit, tobit regressions
 - Evaluate relative significance of variables in predicting spatial patterns
- Model testing - sensitivity analysis and model validation



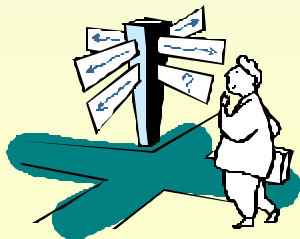
Evaluating Exposure

- Our research considers regional trends and patterns, not assessing exposure at specific locations
- Capitalize on high-quality secondary data; use it in innovative ways
- Data Characteristics
 - What is available/missing?
 - Locational accuracy, spatial resolution
 - Weighting – e.g. HAPs – mobile vs. stationary; differences in toxicity
- Other Important considerations – analytical unit, geographic extent, accuracy, spatial resolution, raster/vector data model, appropriate geographic projection)

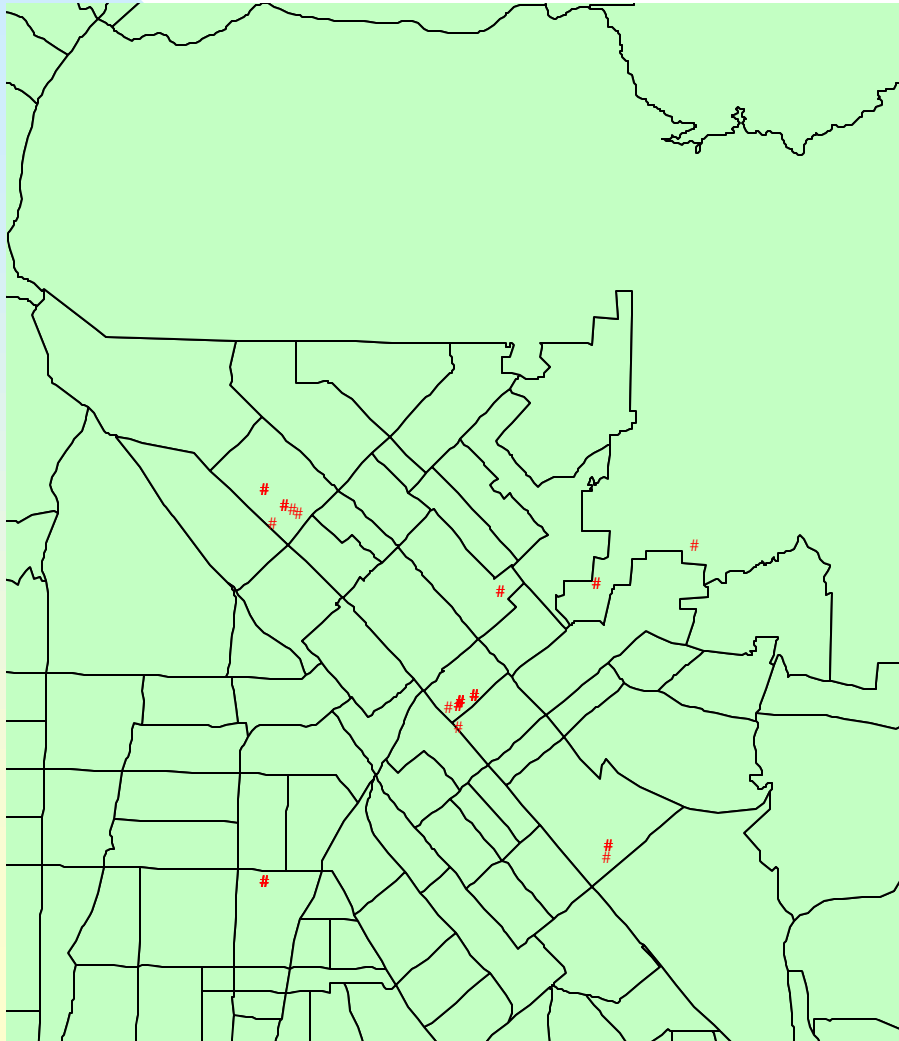


Evaluating Exposure.....

- Census/school demographics require vector model (transfer attributes to polygons; aggregation, avoiding misclassification).
- Locate emissions or sources by geocoding; (error checking using GPS and air photos)
- Actual vs. potential exposure
 - e.g. TRI vs. TSD (actual or potential release)
- Exposure characteristics
 - Distance/decay function
 - Dispersion characteristics (wind)
 - Stability (rainout, photodegradation)
 - Mode of exposure (inhalation, dermal, etc.)
 - Bioconcentration, bioavailability

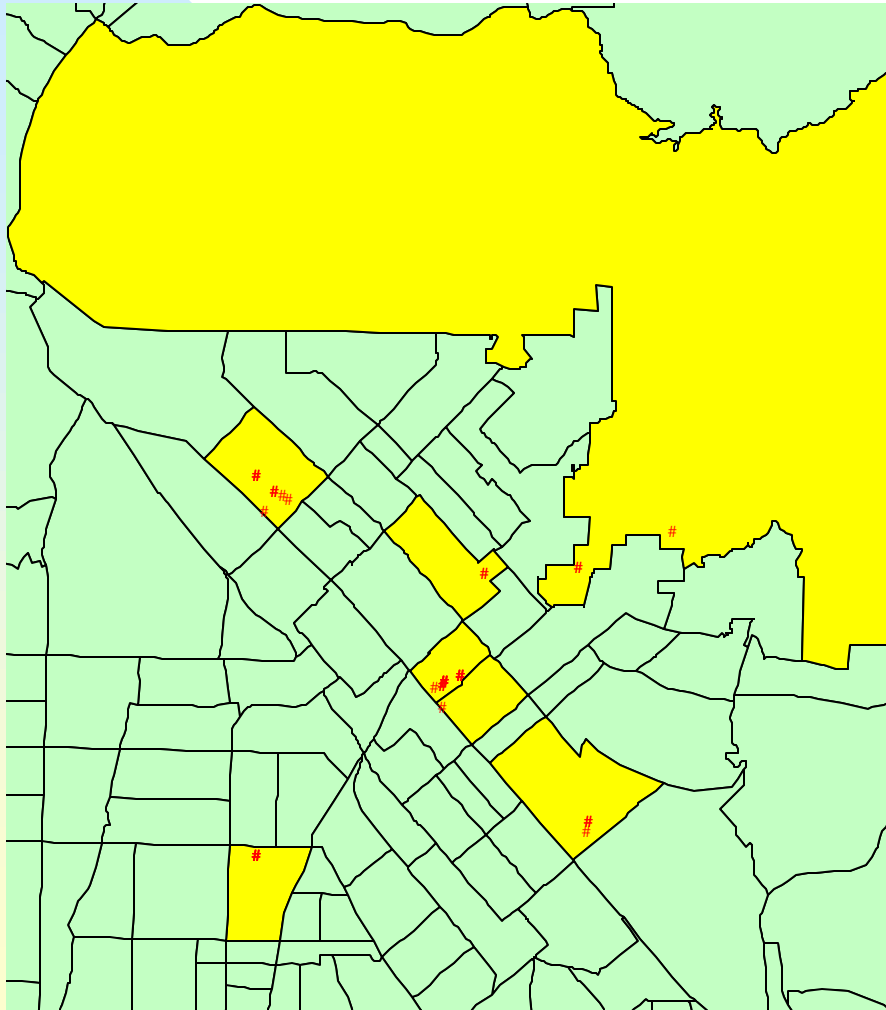


Exposure Determined Based on Proximity

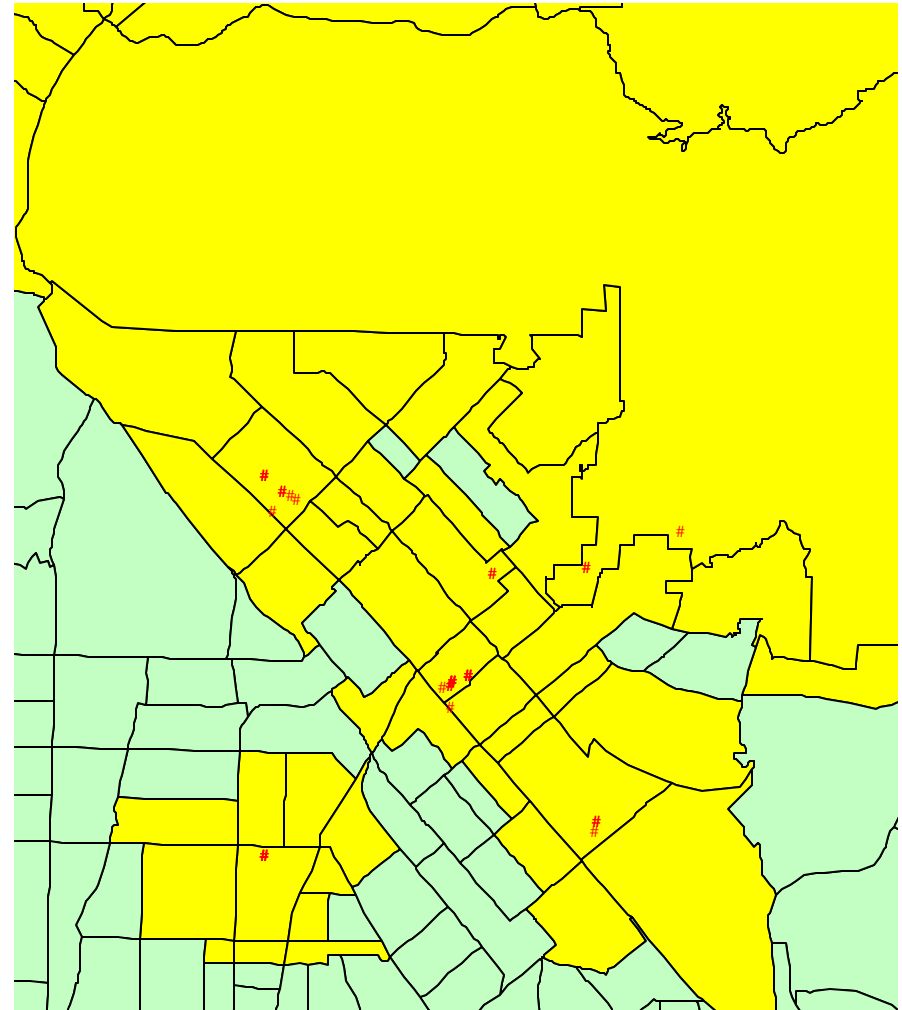


- Census tracts from NE Los Angeles County
- 2000 TRI air release sites (>0)
- TRI – point features
- Who/where is exposed?
- How to characterize proximity?

Tracts Which Contain Sites -



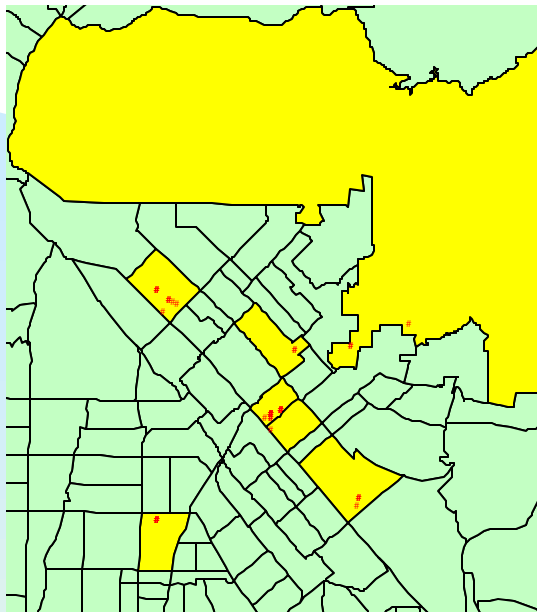
Tracts containing sites



Tracts adjacent to host tracts

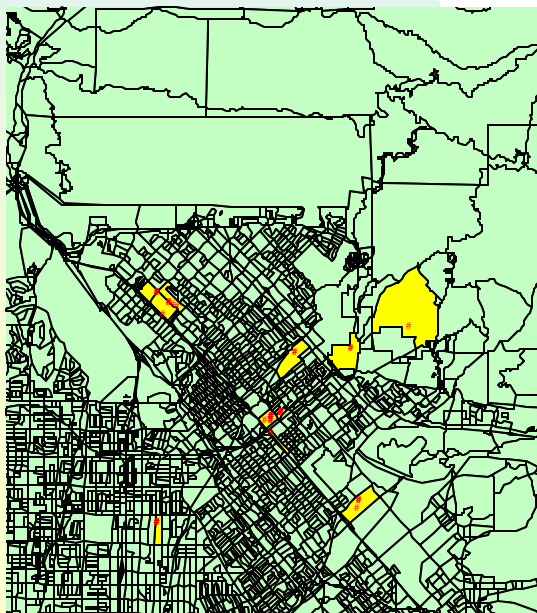
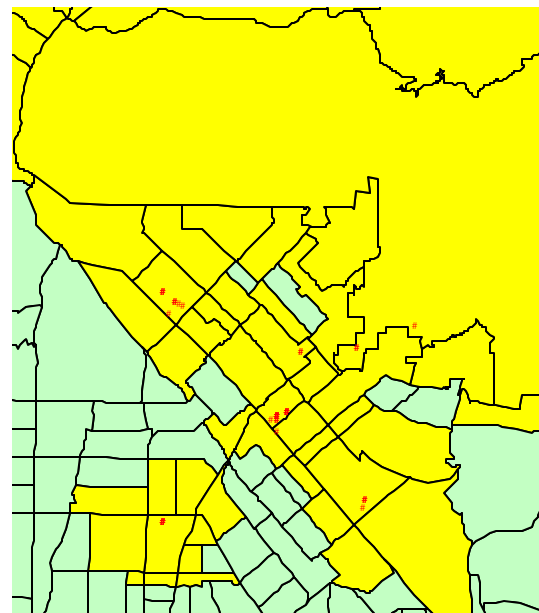
Advantages/Disadvantages

- Easy analysis, no need for a GIS
- Has been widely used in EJ research, no longer common
- No consideration of geography or spatial location
- Assumes equant tract polygons, sites in center of tract
- Non-spatial consideration of neighboring tracts
- Often misclassifies tracts
 - Host tract only under-represents exposure
 - Adding adjacent tracts includes non-proximate tracts
- Some improvement using smaller polygons (blocks)



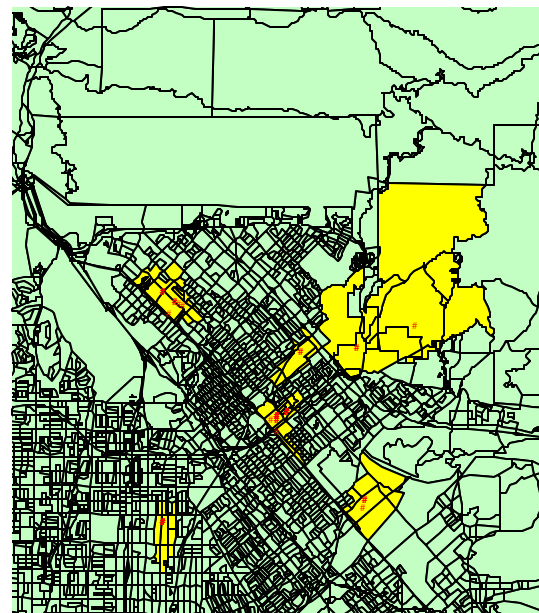
**Census tracts
containing sites**

**Add adjacent
tracts**

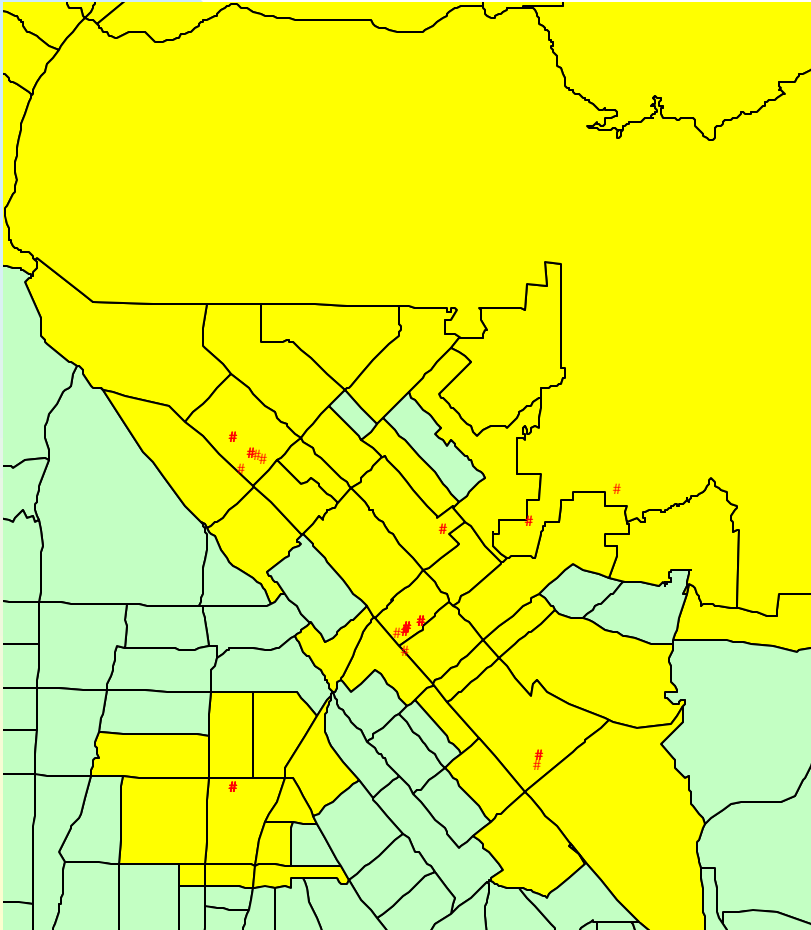


**Census blocks
containing sites**

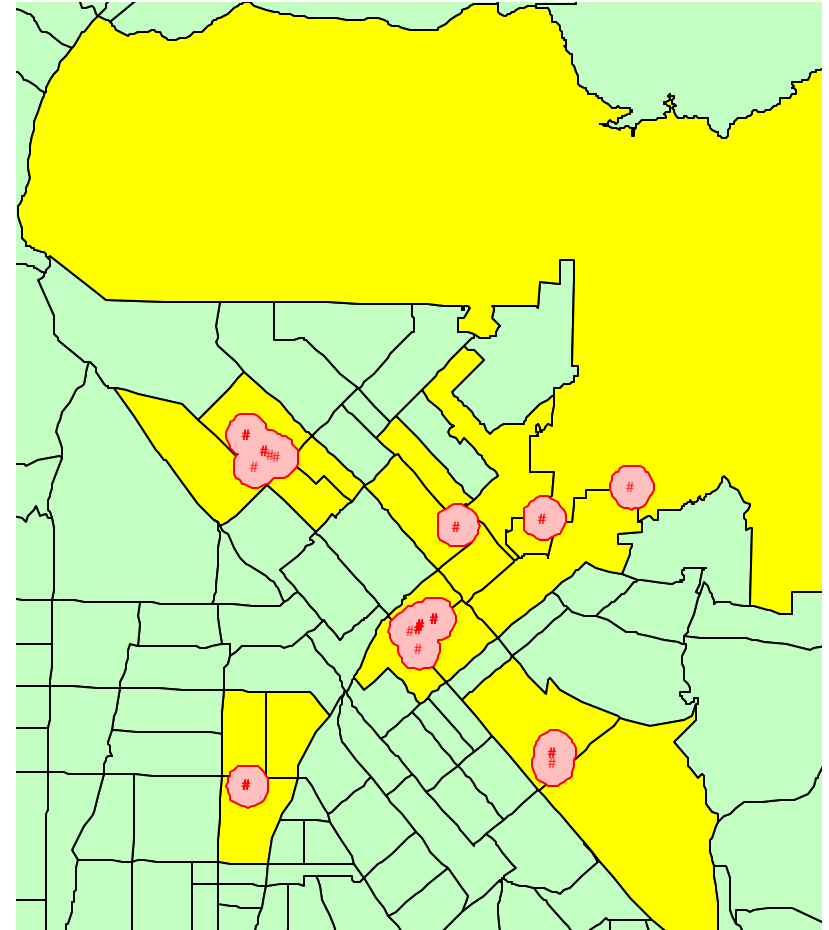
**Add adjacent
blocks**



Circular Buffers Around Sites -



Tracts adjacent to host tracts



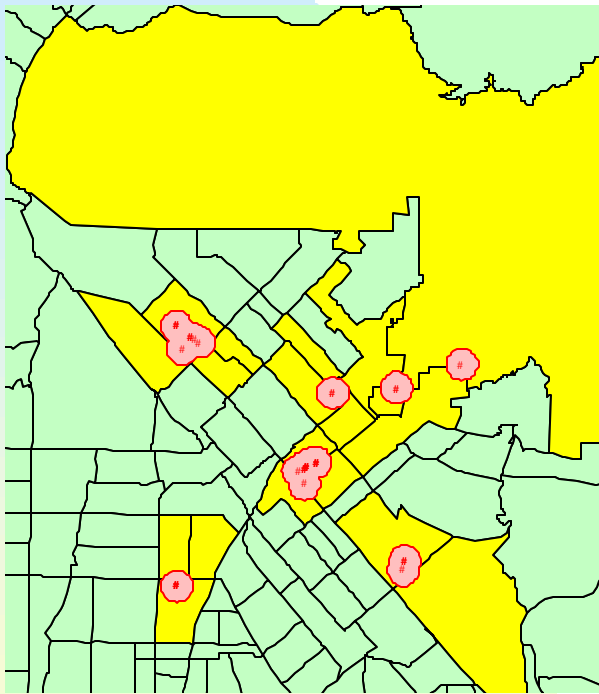
0.25 mile buffers capture adjacent tracts

Advantages/Disadvantages

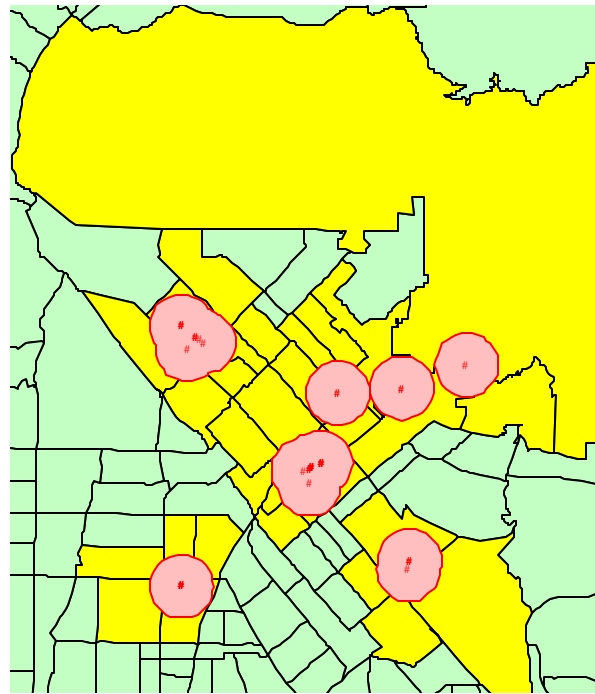
- Improvement over “host tract” method
- Considers geography and location
- Allows flexible consideration of distance
- Reduces misclassification of distant tracts
- Dispersion/exposure probably non-circular (but, residents travel locally)
- Cannot continuously represent non-linear distance/decay relationship
- Misclassification increases as buffer radius approaches tract size

Effect of Buffer size:

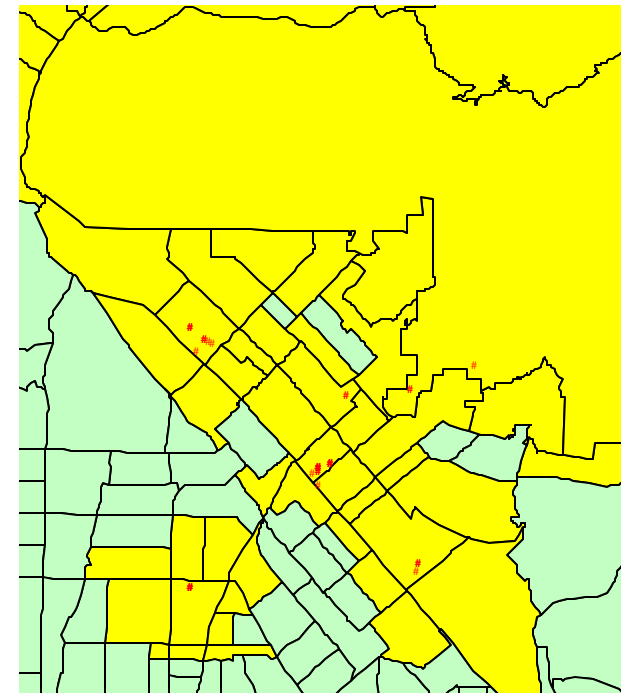
Increase buffer size to reflect median tract area



0.25 mile buffers



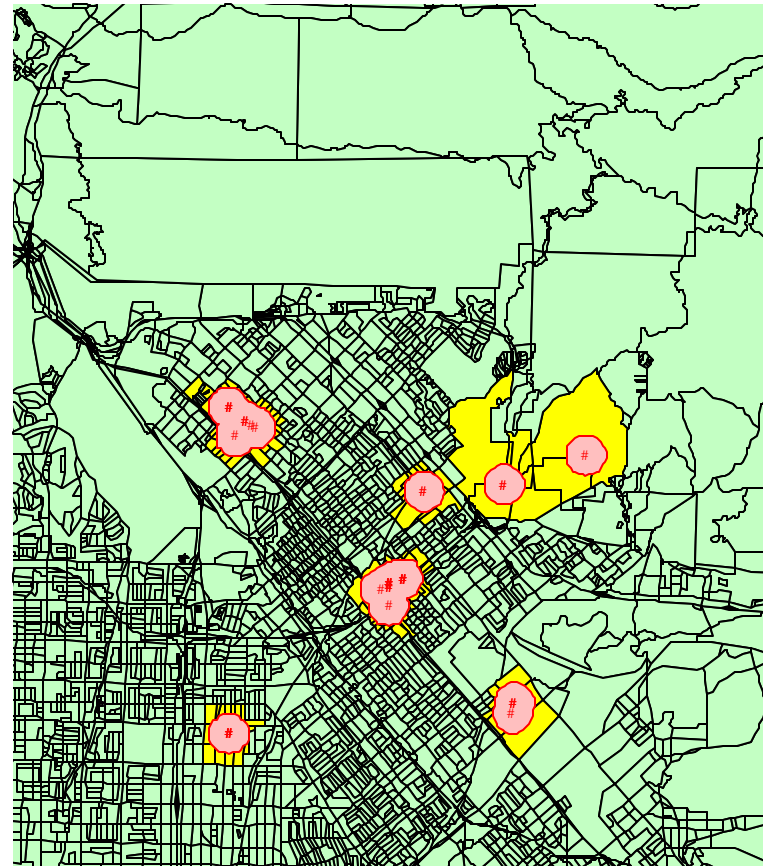
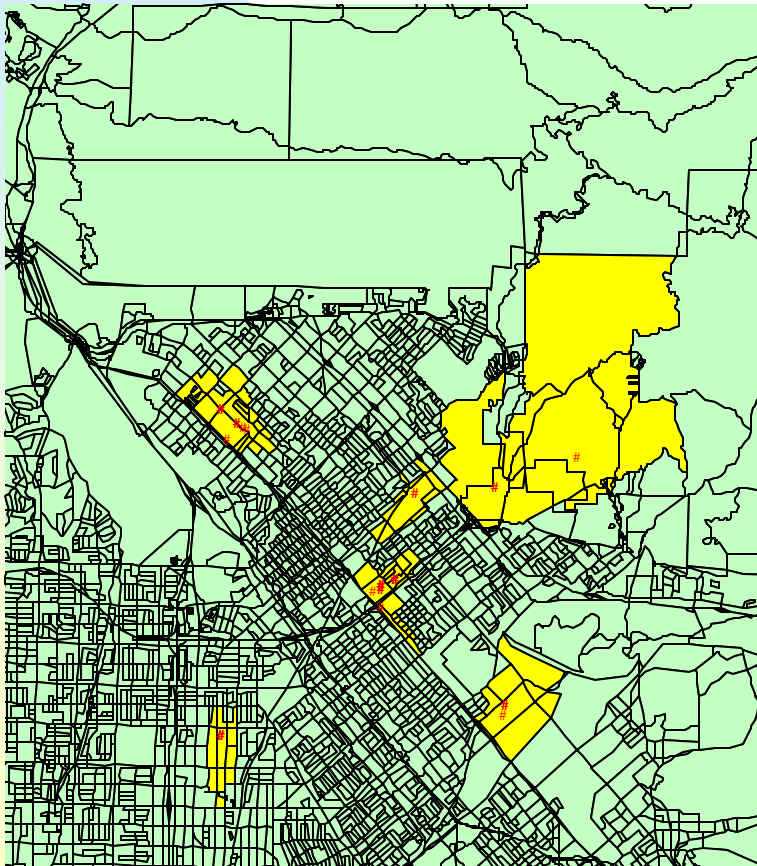
0.50 mile buffers
(median tract size)



Host and adjacent
tracts

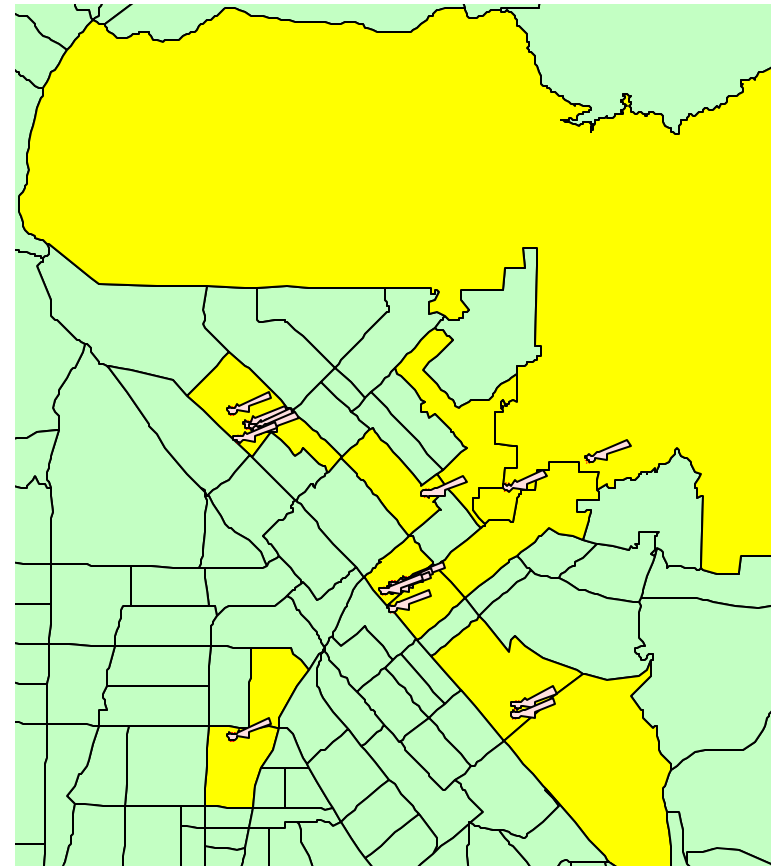
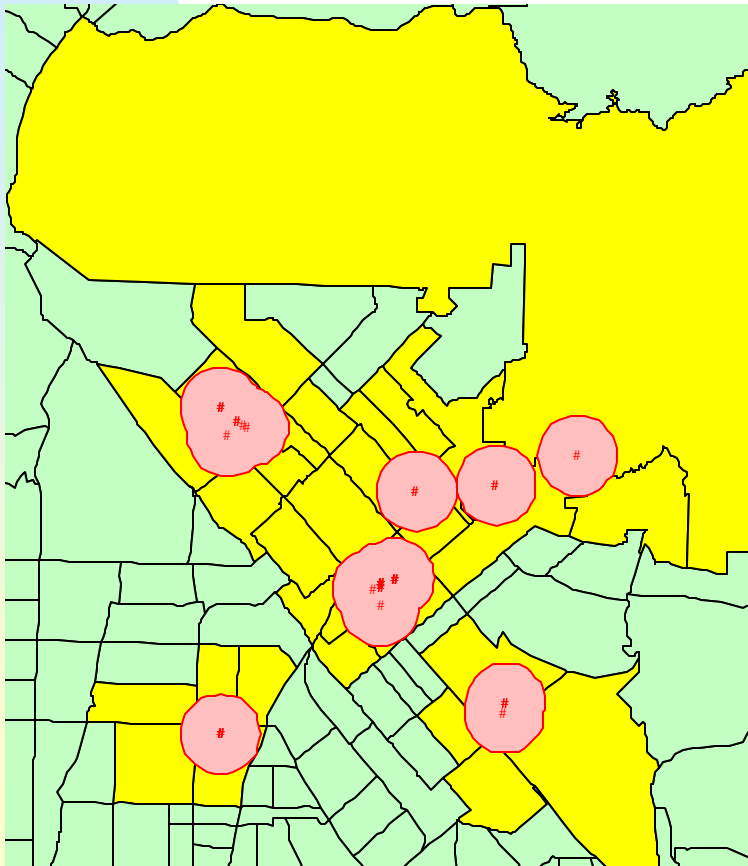
Census Blocks instead of Tracts

- Some improvement over “host tract” method
- Buffers still reduce misclassification
- Some demographic information missing at block level



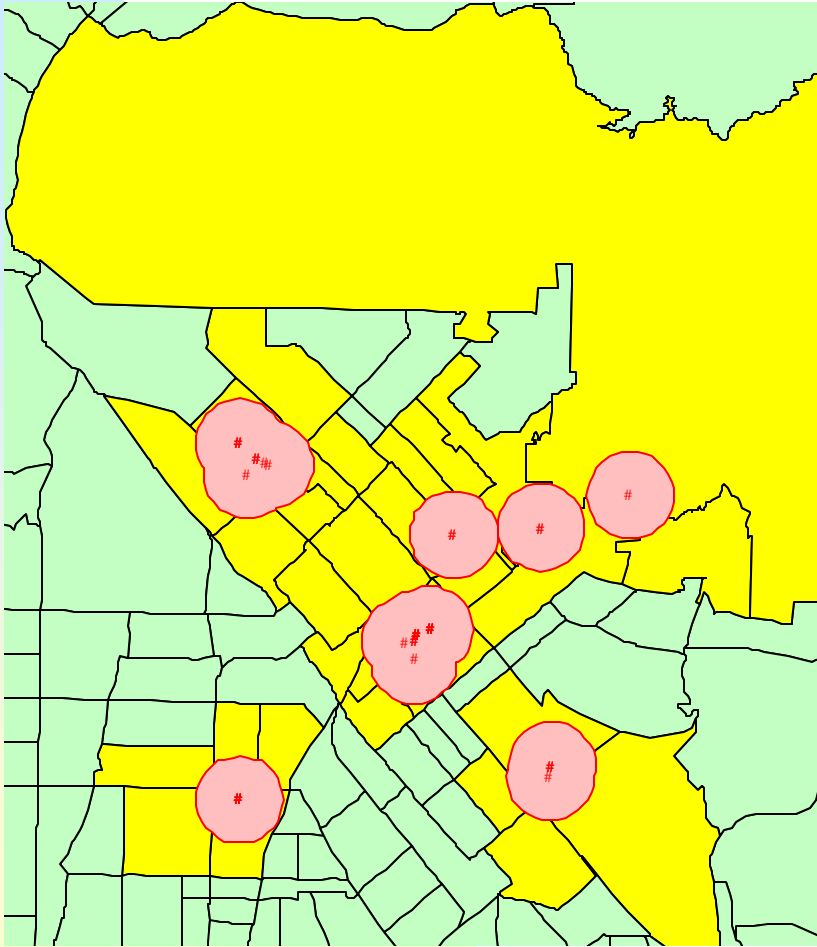
Non-circular Buffers

- Reflect dispersion (use wind rose information)
- Further reduce misclassification

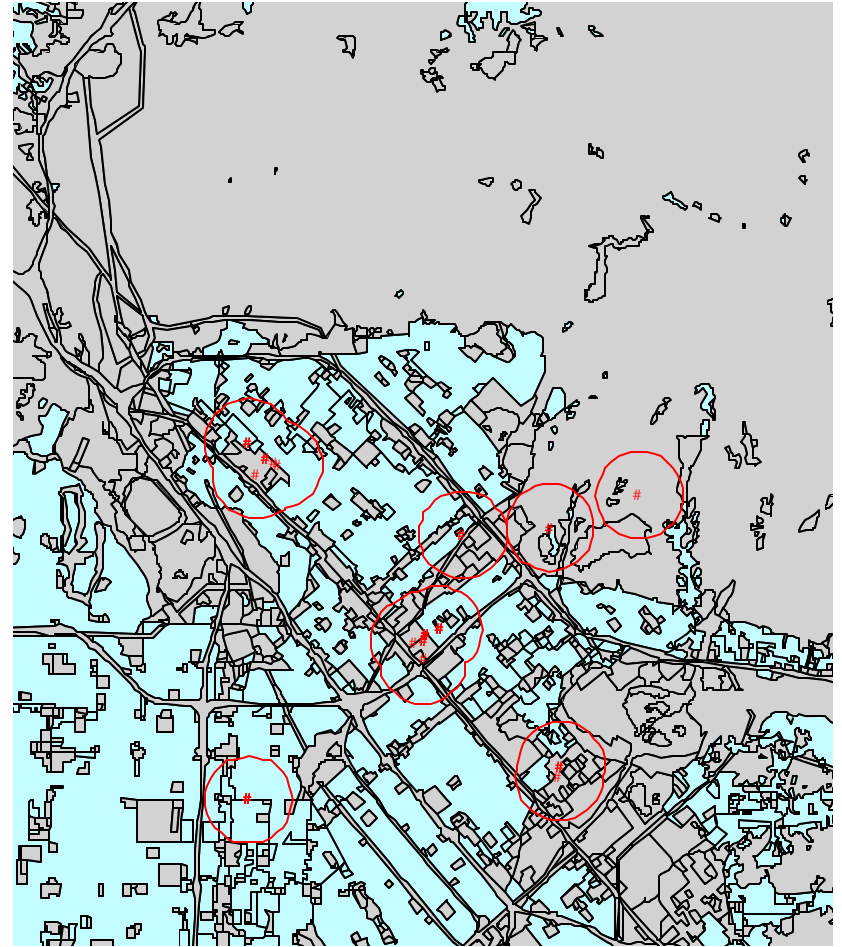


Circular buffers vs. wind rose polygons scaled to 0.5 mile radius

Land Use Information Reduces Misclassification



Tracts; 0.5 mile buffers



Residential land use;
0.5 mile buffers

Other Approaches –

More Complex and Precise Raster Data Models

- Calculate exposure plume “footprint” or distribution asymmetry of airborne releases
- Use climatic conditions, quantities and physical properties of chemicals released (time-averaged or time-weighted)
- Plume models (E. Sheppard, et al., Univ. Minnesota)
- Exposure-Weighted Spatial Filtering (H. G. Claycamp et al., USFDA)
- Question of whether effort/time expended in applying this more precise method outweighs implementation costs.
- Highly dependent on seasonal wind patterns.
- Some results support disproportionate exposure

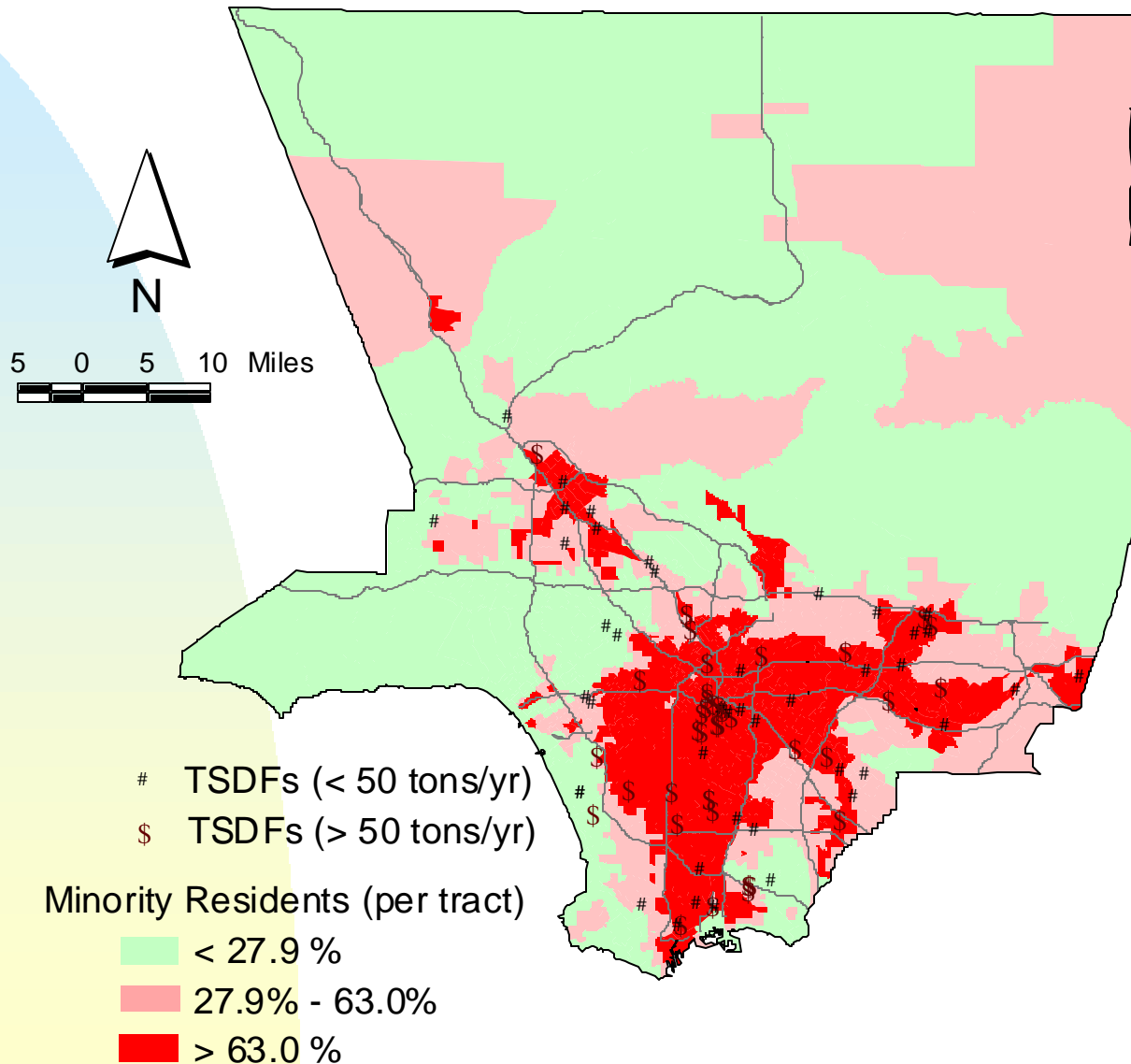
EPA Cumulative Exposure Project

- National-scale effort to assess environmental and public health impacts from toxic substances exposure
- Includes modeled long-term annual average concentrations for 148 hazardous air pollutants (HAPs) listed under the 1990 Clean Air Act Amendments
- Uses existing inventories of emission sources
- ASPEN model used to estimate HAP concentrations by calculating dispersion patterns after release
- Considers location, height and rate of release; local wind characteristics; decay, settling and chemical transformation after release
- Air monitor data used to calibrate model; model tends to under-predict about 3/4 of the time.
- Includes mobile and stationary sources

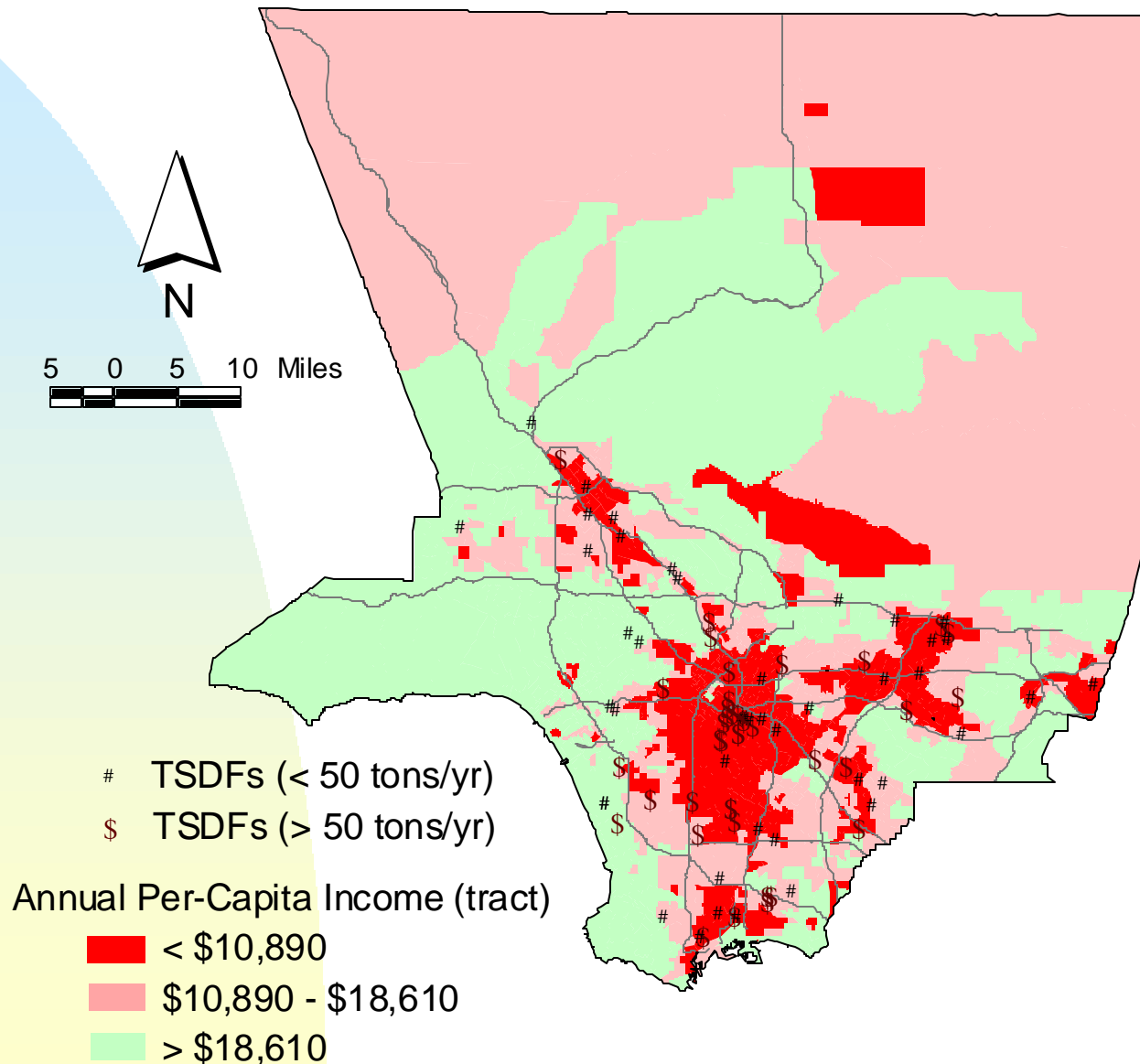
EPA CEP – Factors to Consider

- States often have superior inventories of emission sources and monitor data, and apply the EPA methodology for their own cumulative exposure analyses (e.g. Minnesota Pollution Control Agency <http://www.pca.state.mn.us/air/at-cep.html>)
- Data access to public withheld/limited
 - Silicon Valley Toxics Coalition – CA maps on the web http://www.mapcruzin.com/svtc_cep/
- Toxicity weighting applied to relate cumulative exposure to estimated health impacts
- If dose/response data is insufficient, EPA applies a 10X safety factor to consider effects on children's health (EPA policy derived from Federal Food Quality Protection Act – pesticides in food)

Pattern of Disproportionate Exposure?

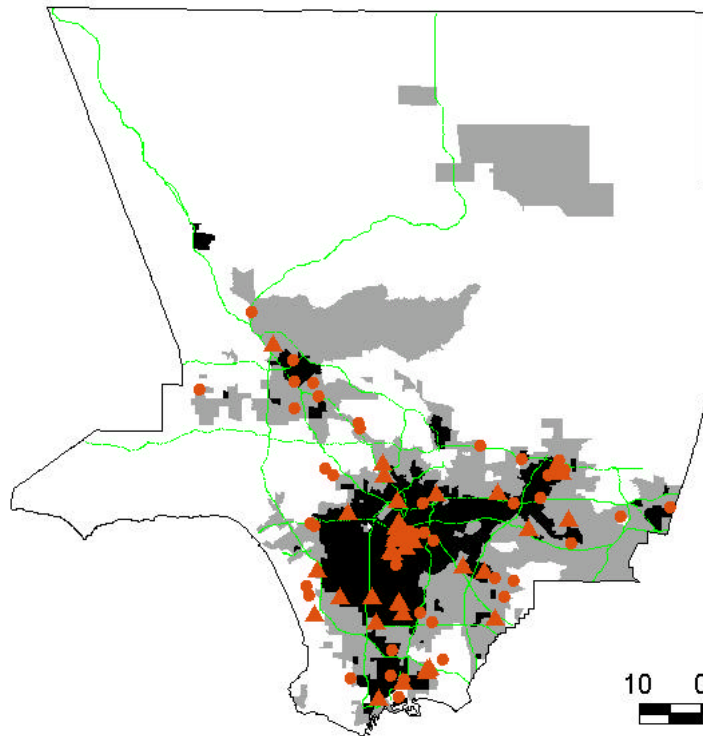


But, Income is Highly Co-correlated -

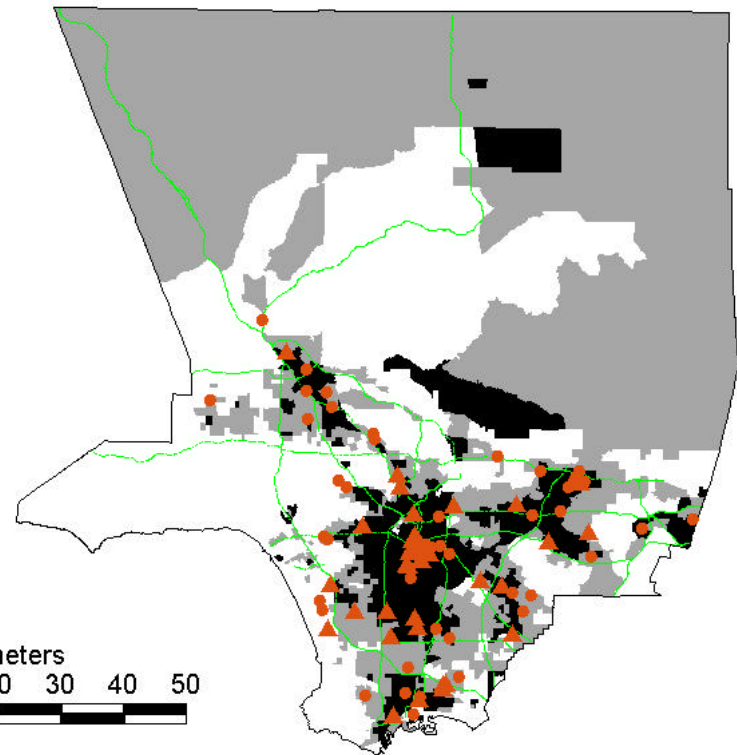


Is There Equity, or a Problem?

Co-correlation may indicate efficient market forces
Bivariate statistics suggestive only



Tract level % Minority Residents
Quantile distribution



Tract level Per Capita Income
Quantile distribution

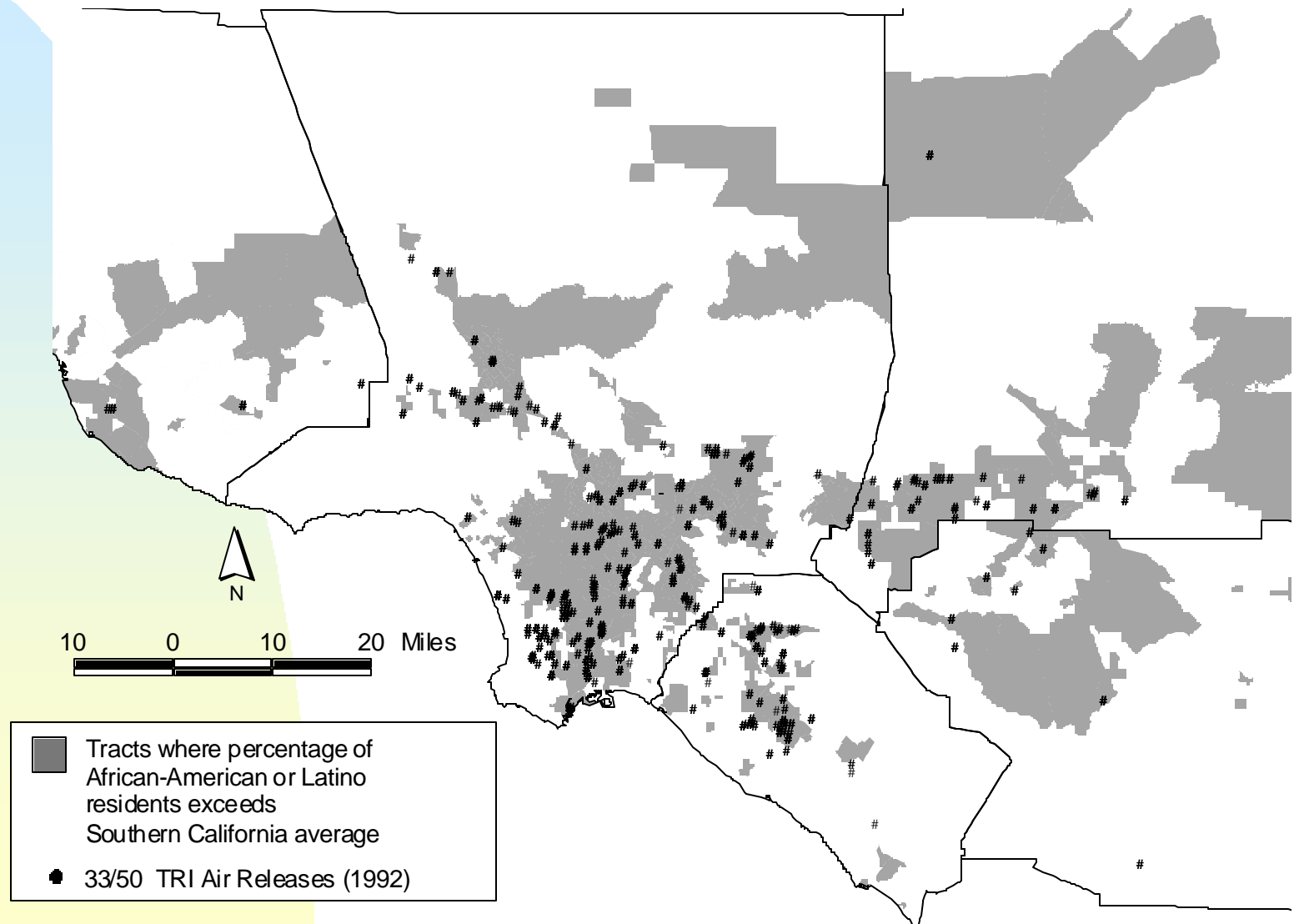
- TSDFs - less than 50 tons/yr
- ▲ TSDF greater than 50 tons/yr

“Teasing Out” Determinants Requires Multivariate Analysis

- **Co-correlation** – some variables highly co-correlated
 - median home value vs. per capita income ($r^2 = 0.81$)
 - % minority vs. % unemployment ($r^2 = 0.70$)
 - % minority vs. % high school education or less ($r^2 = 0.82$)
- **Spatial Auto-correlation** – tract demographics correlated spatially with neighboring tracts (continuous variable)
- **General form of regression:**

TSDF or TRI Location:
= f { % Minority (+), Income (+), Income² (-),
% Industrial Land Use (+),
Manufacturing Employment (+), Population density (-) }

TRI Air Releases and Race Metropolitan Los Angeles Area



Sample Logit Regression Results

TRI Air Releases (1992 TRI vs. 1990 Census)

Dependent:	<i>Air/1.0</i>	<i>3350/1.0</i>	<i>Carc/1.0</i>	<i>3350/1.0</i>	<i>Carc/1.0</i>
Variable:					
MINORITY	0.014 (24.542) ***	0.015 (22.947) ***	0.014 (20.407) ***		
PERCAPIN	0.015 (12.405) ***	0.021 (14.987) ***	0.016 (10.929) ***	0.022 (12.594) ***	0.015 (7.420)
PERCAPIN2	-4.9E-05 (14.735) ***	-7.0E-05 (15.649) ***	-5.2E-05 (10.807) ***	-7.5E-05 (14.355) ***	-5.0E-05 (8.557) ***
INDUSTRY	0.045 (77.729) ***	0.045 (103.292) ***	0.043 (101.800) ***	0.045 (106.350) ***	0.044 (105.488) ***
EMPMANU	0.098 (187.222) ***	0.109 (214.554) ***	0.102 (196.156) ***	0.105 (187.187) ***	0.099 (172.281) ***
POPDEN	0.0003 (.203)	-0.0018 (6.844) ***	-0.0002 (.142)	-0.0015 (4.895) **	0.0001 (.025) ***
AFAMPCT				0.007 (3.681) *	0.005 (2.515)
LATINPCT				0.016 (15.899) ***	0.013 (11.015) ***
% Correct	71.2%	75.9%	75.5%	75.6%	75.0%

*** Significant at the .01 level

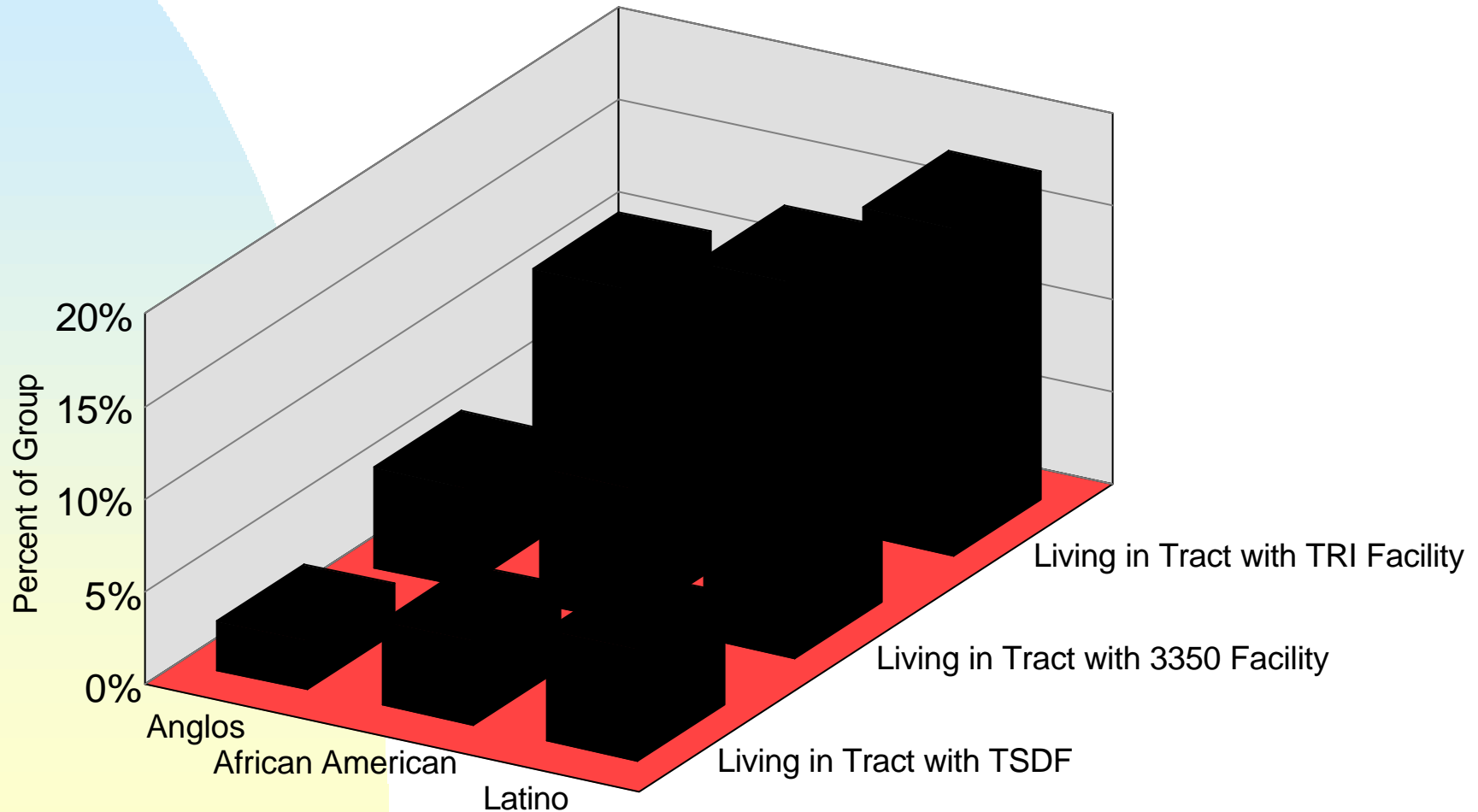
** 0.05 level

* 0.10 level

0.20 level

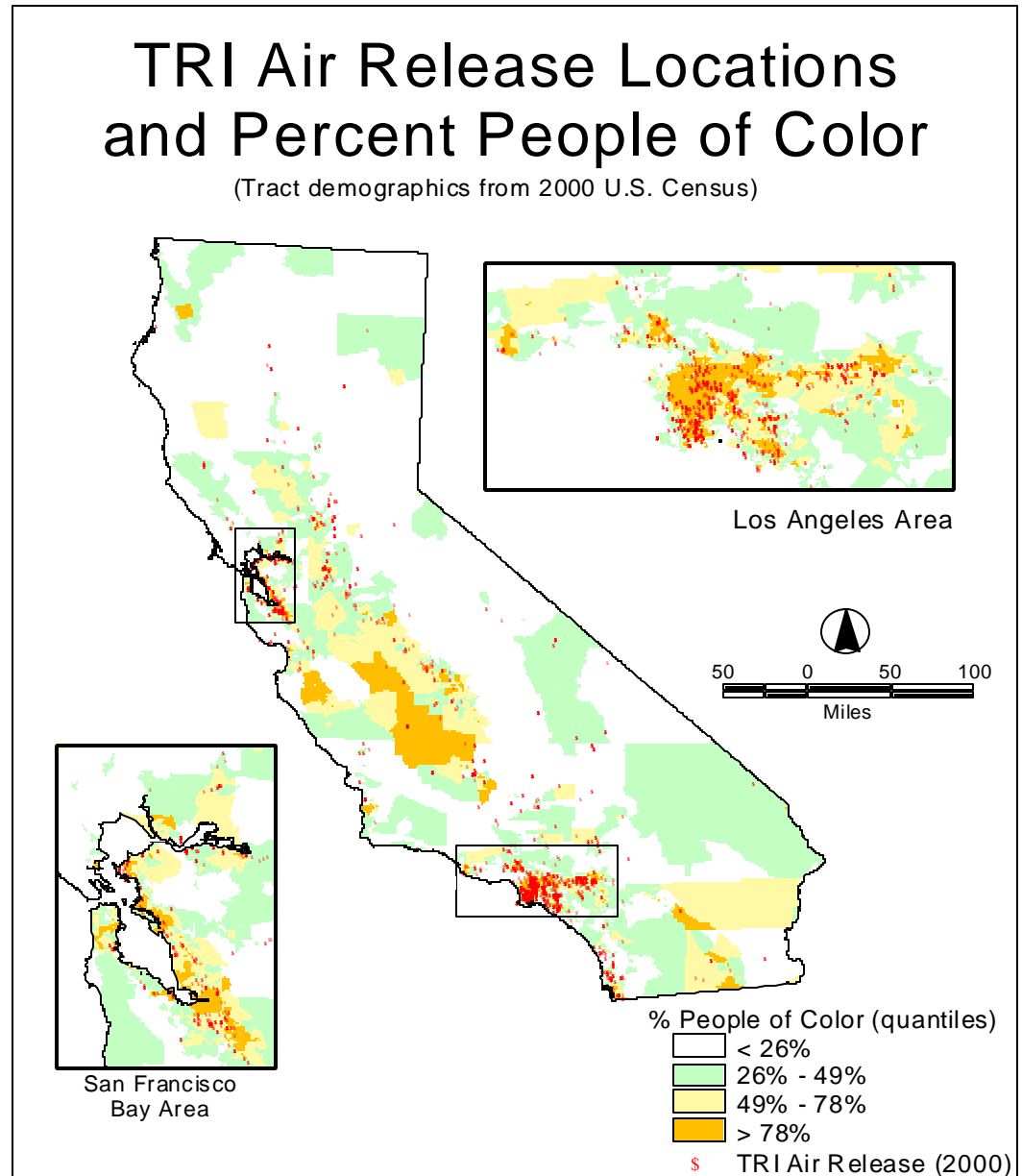
TRI Exposure by Race – So. California

Pattern persists among hazards and with toxicity



Analysis using 2000 TRI and 2000 Census

TRI releases
Statewide and
within urban
areas are
concentrated in
areas with high
% residents of
color



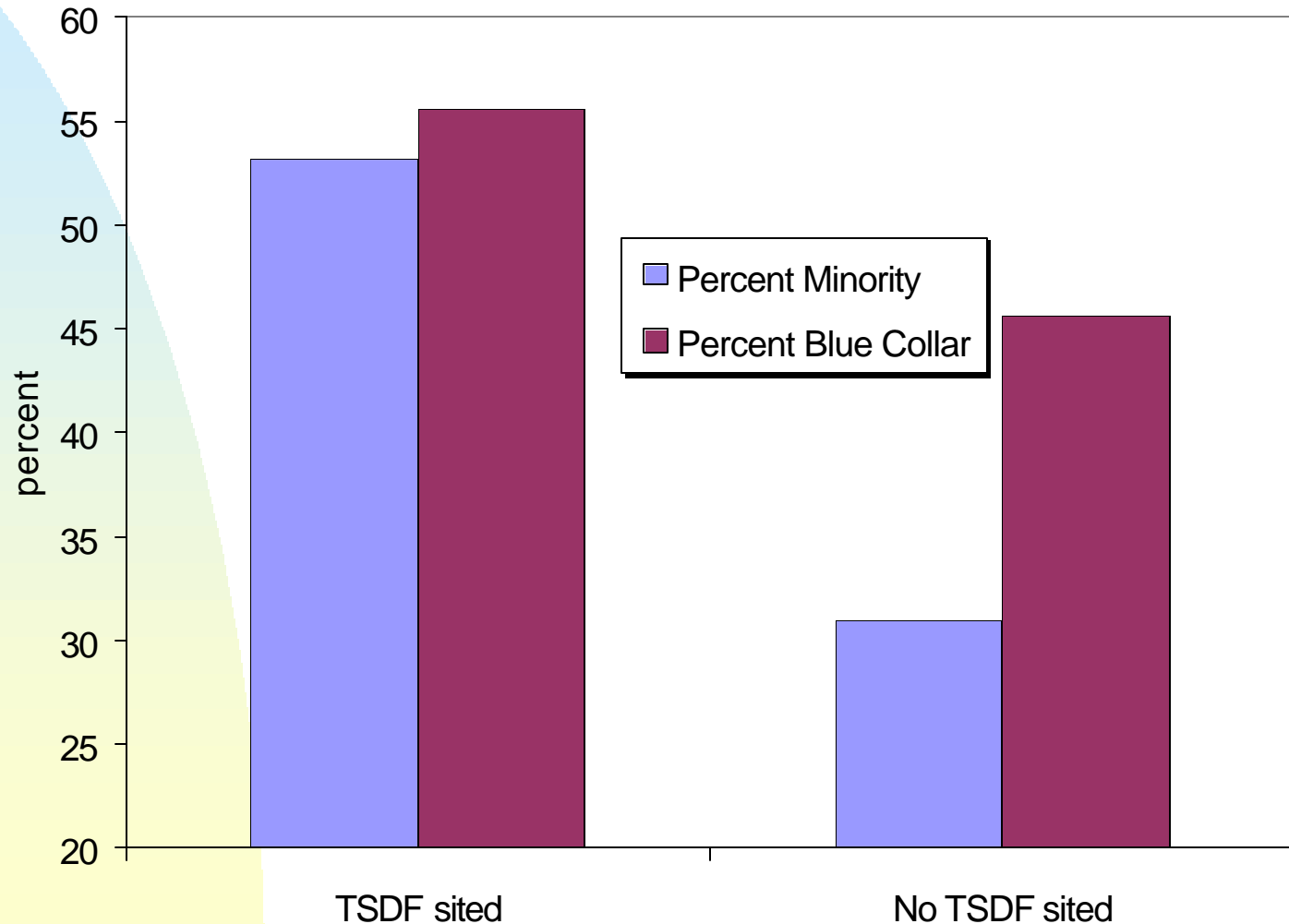
Multivariate Regression Results Considering Degree of TRI Hazard

- Disparities are persistent and significant over time and space
- Racial disparities hold even after controlling for income and other key factors

Ordered Logit (0 for no releases, 1 for air releases, 2 for carcinogenic releases)				
	Model 1		Model 2	
	Direction of Effect	Stat. Sig.	Direction of Effect	Stat. Sig.
% people of color	+	***		
% home owners	(--)	***	(--)	***
median household income	(--)	*	+	ns
% manufacturing employees	+	***	+	***
population density	(--)	***	(--)	***
% Latino			+	***
% African-American			+	***
% Asian Pacific Islander			+	***
*** highly significant (at the 1 % level)	N= 7015		N= 7015	
** very significant (at the 5 % level)				
* somewhat significant (at the 10 % level)				
ns not significant				

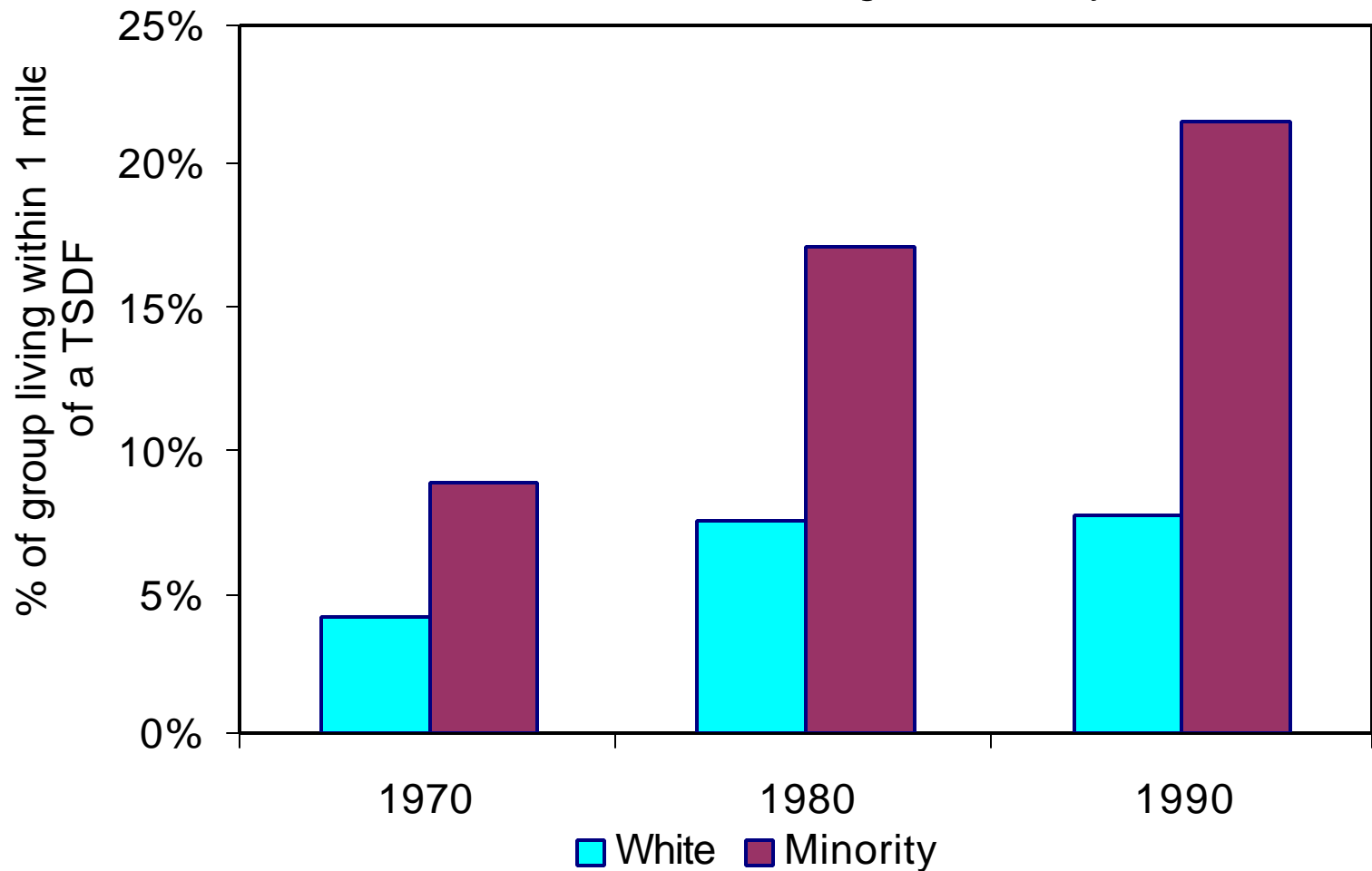
Significant Differences at Time of Siting . . .

Demographics of Areas to Receive Facilities, 1970-90



Disparities in Exposure Have Actually Increased Over Time

Proximity (1 mile) to High-Capacity TSDFs
over Time in Los Angeles County



Is There Also Disproportionate Cumulative Exposure and Health Risk?

- Regional pattern of estimated lifetime cancer risk posed by cumulative exposure to outdoor ambient air pollution (“riskscape”).
- Quantitatively evaluate any disparities in estimated individual lifetime cancer risks among diverse populations.
- Used cumulative exposure model results - US EPA’s Cumulative Exposure Project
 - Modeled long-term annual average for 148 hazardous air pollutants (HAPs) listed under the 1990 Clean Air Act Amendments
 - Toxicity weighting gives health risk estimates



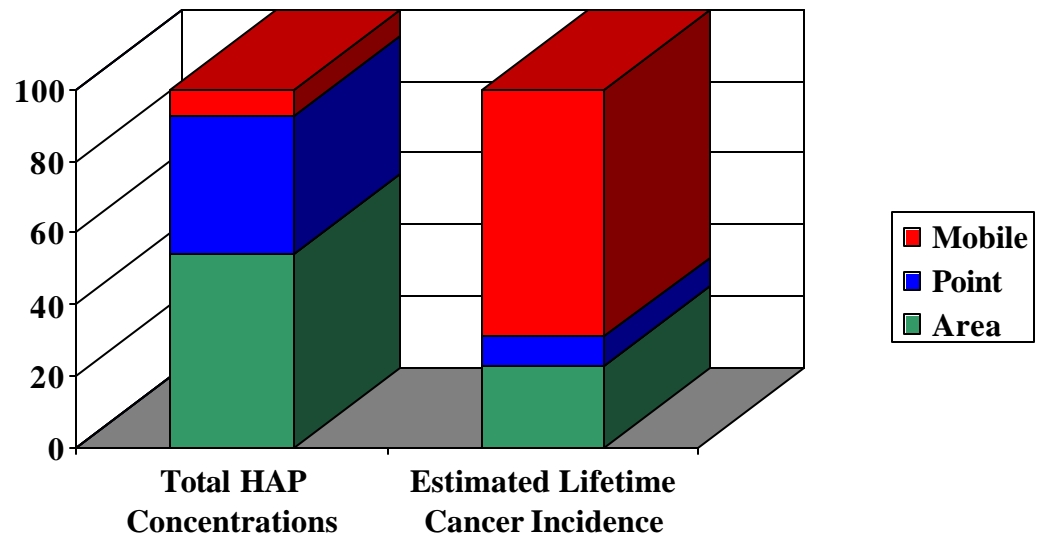
Health risks associated with HAPs are high throughout the South Coast Air Basin

Often exceed Clean Air Act Goal of 1 in 10^6 by between 1-3 orders of magnitude

Mobile sources are largest contributor; most concern about health risk from diesel emissions

High point and area concentrations in some areas result in significant local non-transportation HAP exposure

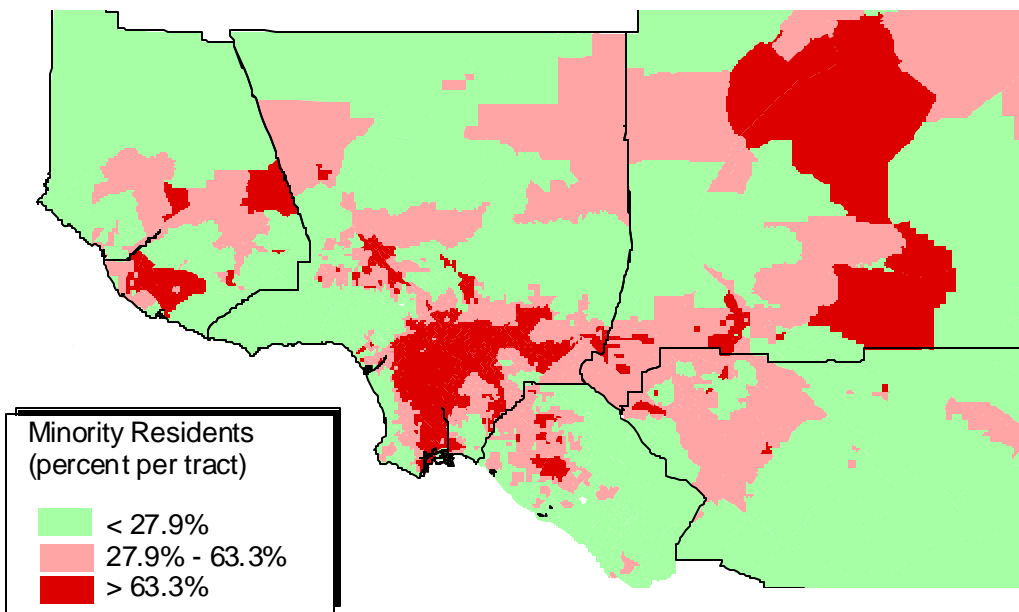
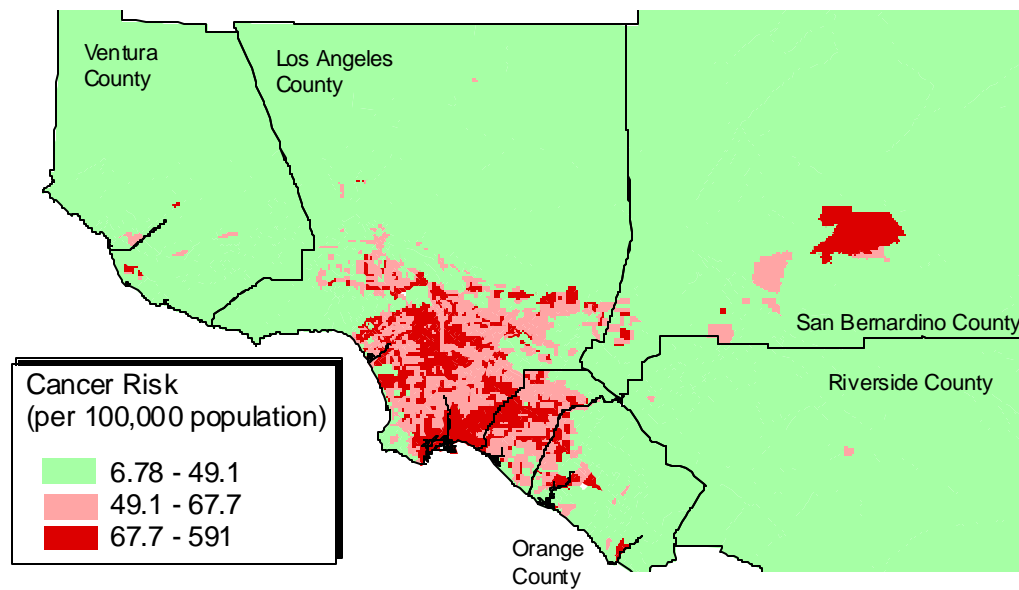
Figure 1: Emission Source Contributions to Air Toxics Concentrations and Estimated Lifetime Cancer Incidence in the South Coast Air Basin



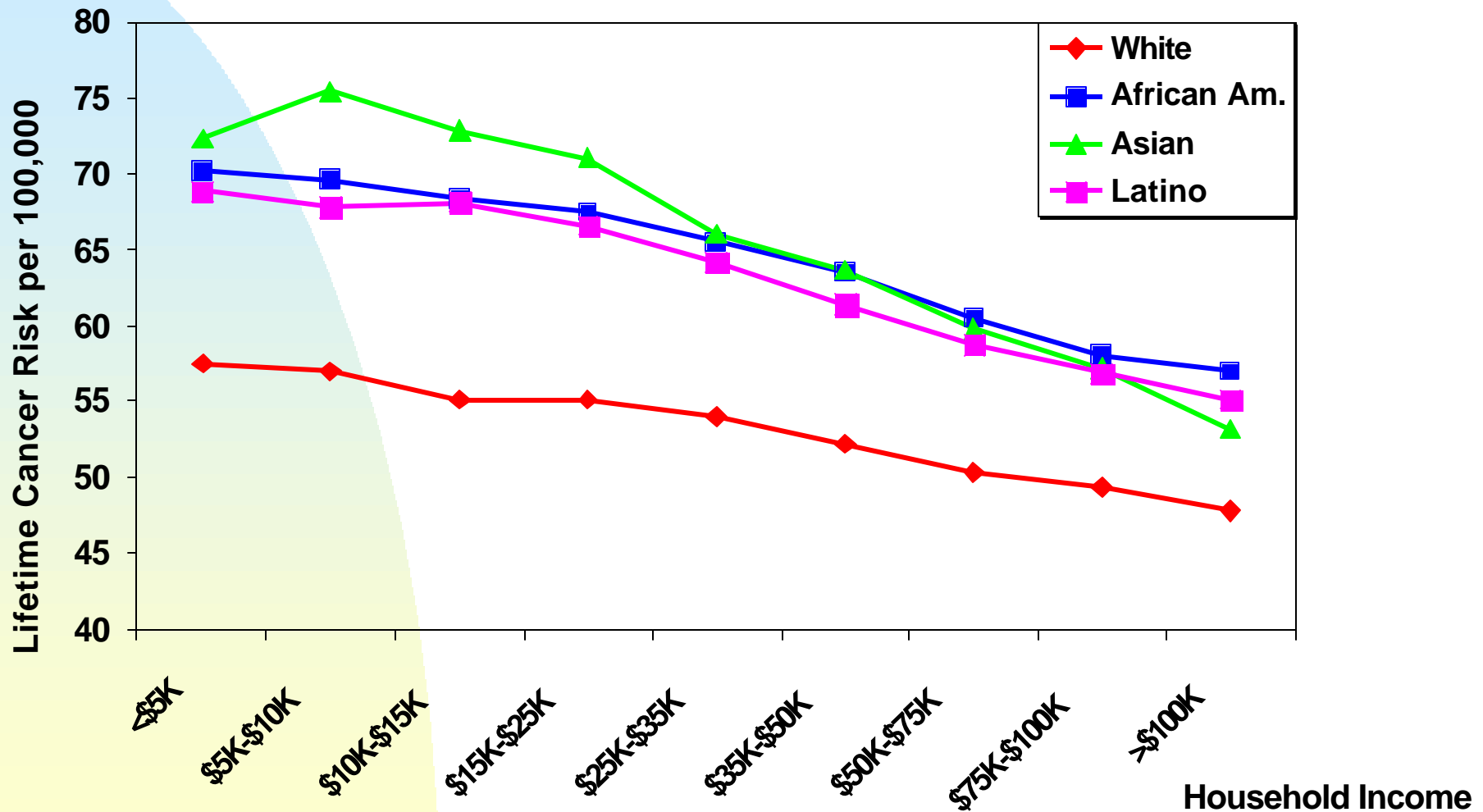
Note: Mobile sources include onroad and offroad vehicles, area sources include small manufacturing and non-manufacturing facilities, and point sources include large manufacturing facilities such as TRI sources.

Cumulative Lifetime Cancer Risk and % Minority Residents

Ambient air exposure to 148 HAPs
(Clean Air Act 1990 Amendments)
Southern California

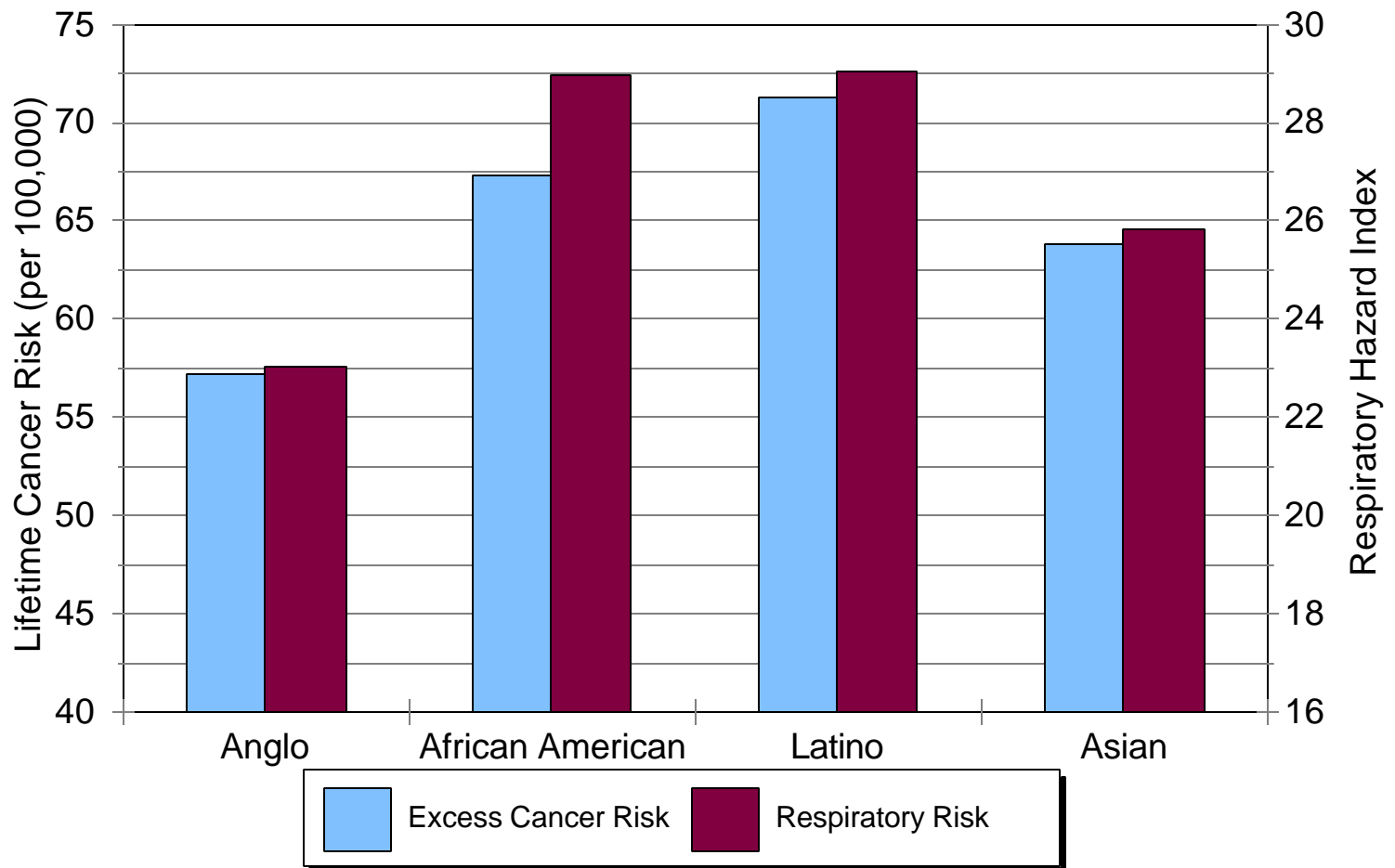


Disparities persist across income strata



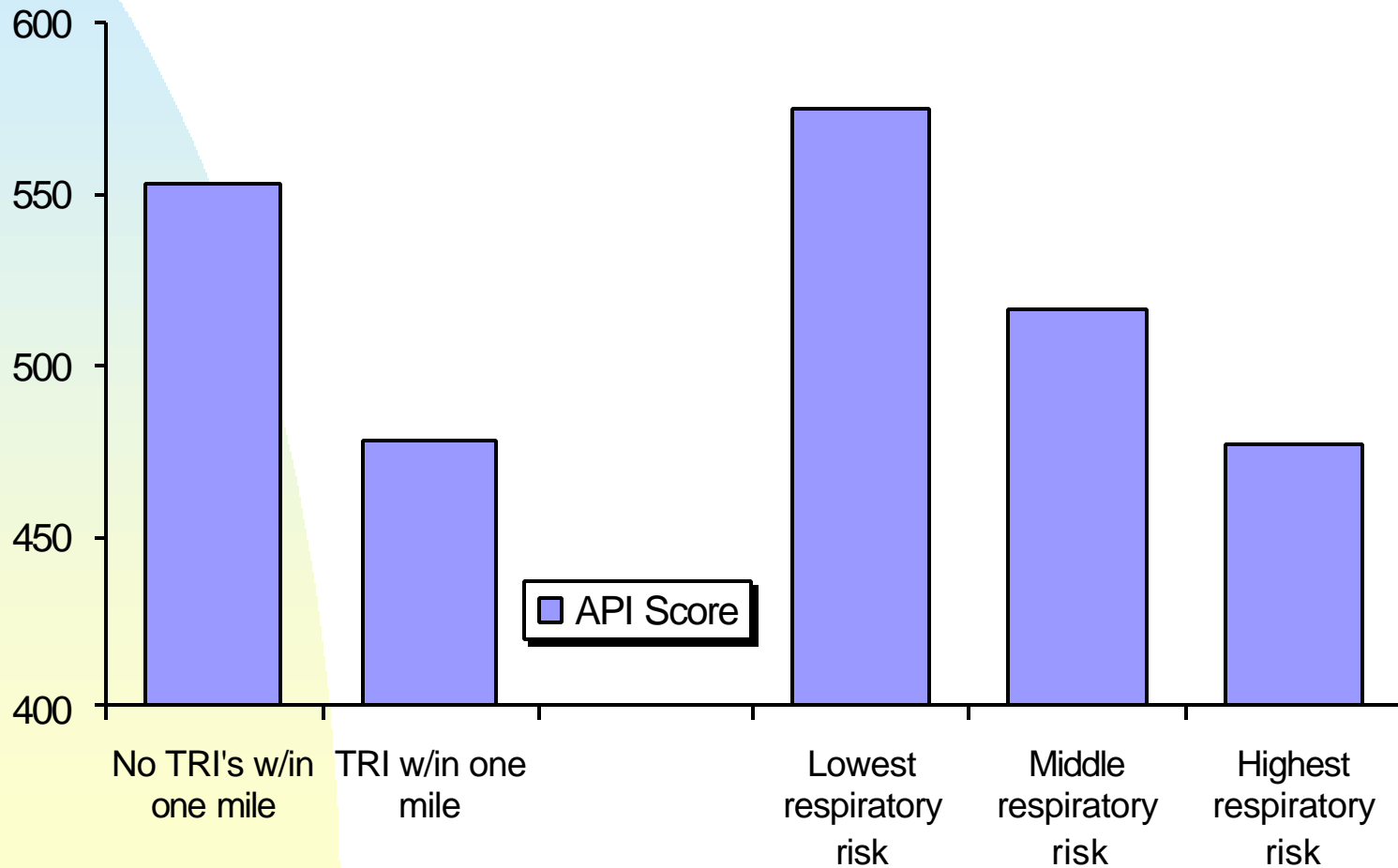
Cumulative Exposure and Risk is Unequal for Children As Well...

**Cancer and Respiratory Risks
for Schoolchildren by Race, LAUSD**

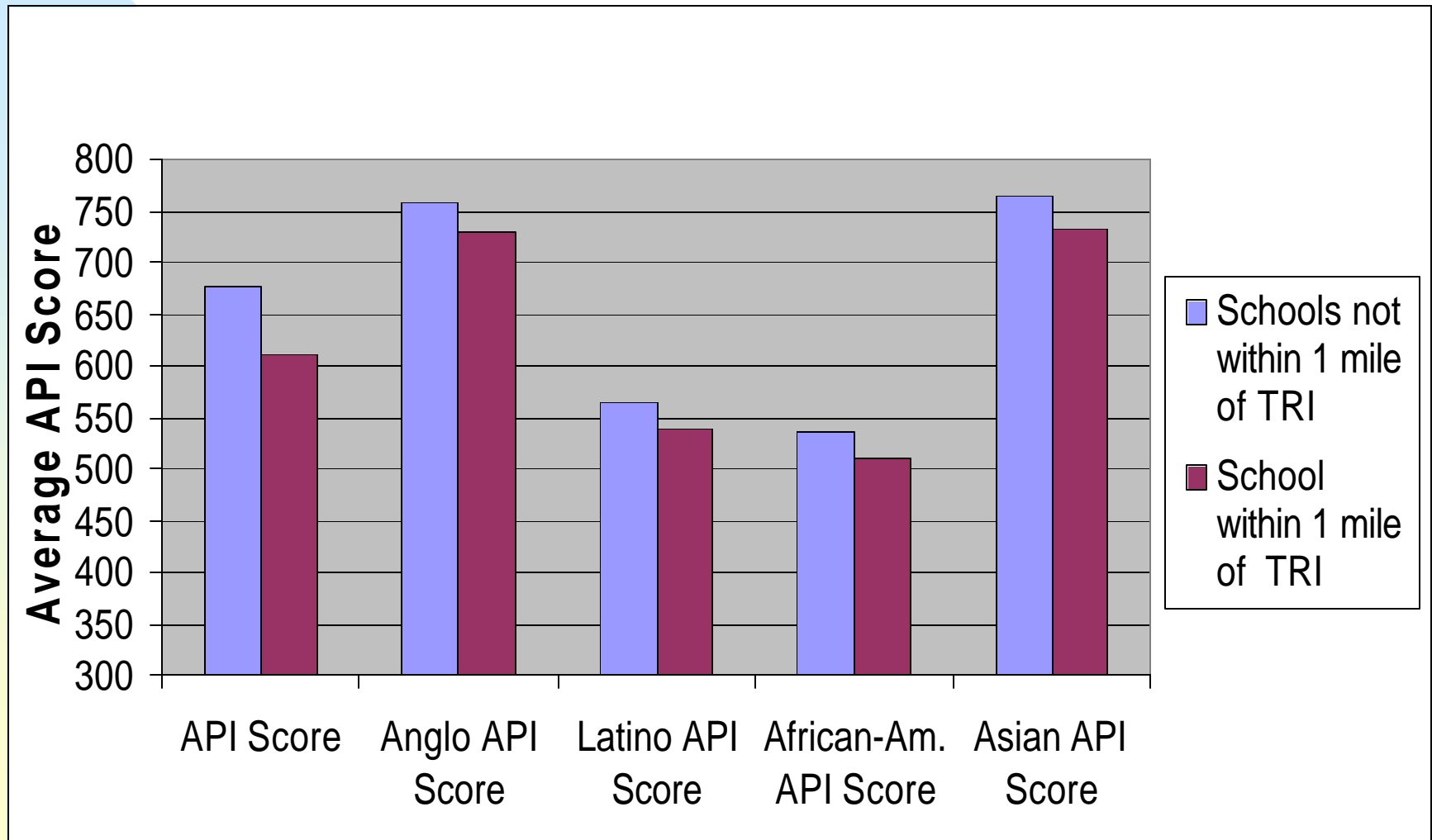


The Disparities Can Have Consequences for Academic Performance

API Score by Environmental Ranking



Repeat Analysis using 2000 data (TRI, API, CBEDS)



	Direction of Effect	Stat. Sig.	Direction of Effect	Stat. Sig.	Direction of Effect	Stat. Sig.
TRI facility with air releases within 1 mile	(--)	***	(--)	***	(--)	***
% of students receiving subsized meals	(--)	***	(--)	***	(--)	***
% of English learners	(--)	***	(--)	***	(--)	***
% of emergency credentialed teachers	(--)	***	(--)	***	(--)	***
% of students for whom this is first year in the school	(--)	***	(--)	***	(--)	***
size of school	(--)	***	(--)	***	(--)	***
% of parents lacking high school education	(--)	***	(--)	***	(--)	***
% Latino or African-American students			(--)	***		
% Latino students					(--)	***
% African-American students					(--)	***

N = 6214
*** Significant at the 1% level

Environmental (In)Justice in Southern California: Research Results

Persistent racial/ethnic disparities in:

- Location of industrial facilities and hazardous waste TSDs
- Original siting explains pattern of disparate impact, not “minority move-in”
- Exposure to TRI air releases (1992, 2000), cumulative ambient air pollutant concentrations and associated health risks
- Environmental hazard exposures among public school children correlates with adverse impacts on academic performance
- Burdens fall most heavily on Latinos and African Americans (income independent)
- Similar results using 1990 and 2000 Census



Towards a Better Understanding - Needs

■ Data

- Most EJ research focused on stationary point sources, with little serious analytical work on transportation
- Need to partition of health risk estimates by emission source
- What is transportation contribution to community health risks? (and, ultimately, to disease)
- We look at this issue with EPA CEP, but need:
 - ◆ information to allow partition at finer level of detail
 - ◆ relative contributions of mobile sources (diesel vs. gasoline)
- Land use information – current and complete from cities
- More accurate locations of emission sources

■ Census Data - Limitations

- Polygons are not random samples
- Problem for many common statistical models
- Spatial autocorrelation
- Resolution of spatial analysis (blocks>tracts, fewer variables)

■ Information to Study Distributional Effects

- How are relative costs/benefits distributed

